

## **CHAPTER 4**

### **COMMUNITY NETWORK PROTOTYPE FOR ENERGY PRODUCTION FROM BIO-WASTE**

This chapter aims to analysis and examine the motivate mechanism for establishment the community cooperation network prototype for Bio-waste separation at source to energy production. The results are received prototype of community and appropriate motivate mechanism with harmonize to cooperation network for Bio-waste separation at source, effective in supporting the electricity generating, with anaerobic digestion method.

The Interdisciplinary Research Approach is applied for investigation such as (1) Documentary research step, study for created criteria to decided experimental area which for establishment a network of Bio-waste separation at source, effective in supporting the electricity generating, with anaerobic digestion method, (2) Operation research step, launch of motivates mechanism for establishment community network i.e. Voluntary Mechanism, Reward Mechanism and Community Business Mechanism. Then, collection data of each mechanism for examine the efficiency i.e. Volume of Bio-waste in Bio-waste collector tank, Proportion of components in Bio-waste collector tank and Percentage of Bio-waste reduction. The details of methodologies for this chapter are explained as following

#### **4.1 Methodology**

##### **4.1.1 Determination for prototype area for study**

###### **4.1.1.1 Prototype city for study**

###### **(A) Criteria for selection**

The prototype area is purposive at Nakornratcha Sriracha Metropolitan. The rational for selected this prototype are as following:

- (1) Nakornratcha Sriracha Metropolitan is located in surveyed area in Chapter 3 which able to apply information for this study.
- (2) Nakhon Ratchasima Metropolitan is processing in the waste disposal project by anaerobic digestion method. So, the result of study is likely to be useful for management in the future.
- (3) Economic incentive is influential for improving behavior in Nakornratcha Sriracha Metropolitan, because the study aim to analyses and examine the motivate mechanism for establishment Bio-waste to energy project which based on economic

incentive i.e. Reward Mechanism and Community Business Mechanism. So, this is should be located on area where economic incentive is influential for improving behavior. According to result of Chapter 3, industrial and commercial city are impacted by economic incentive. Then, Nakornratcha Sriracha Metropolitan, represented of commercial city which many distribution around the country, has potentially for prototype area of this study.

From above rationale, Nakhon Ratchasima Metropolitan is suitable for prototype study area to examine of motivate mechanism for establishment the community cooperation network prototype for Bio-waste separation at source to energy production.

### **(B) Background**

Nakornratcha Sriracha Metropolitan has been selected as a target of establishing networks. Profiles of Nakornratcha Sriracha Metropolitan are as followed. [35]

- **Location:** Location of the metropolitan is the center of the province and located in Muang District, Nakornratcha Sriracha province. The distance from Bangkok is 255 kilometers. The responsible area is 37.5 km<sup>2</sup>, accounted for 4.96 % of districts or approximately 0.18 % of province. Total area is divided into 4 zones according to the district elections.

- **Population:** Population in metropolitan has 170,095 people which accounted for 58,810 households, scattered in 84 communities (September 2007). A hidden population is approximately 22 % of registration population or approximately 40,000 people and a total population of approximately 210,000 people. The metropolitan anticipated that in 2020 the population will be living in this area is approximately 320,000 people which is growing very fast. The majority of the population of is local and refugee from neighboring provinces. The most number of occupations is commercial and services, agriculture and industry are secondary. This will be found of a major corporation and business in the municipality, such as 41 of the hotel, 12 of theater, 21 of gas stations, 40 of banks, 936 of restaurant, 11 of shopping mall and 15 of fresh market ,etc.

- **Waste management:** As this city has many businesses and population, thus affected to solid waste generated approximately 220 tones /day. In the past, that disposal by landfill, covering 189 rai already used about 100 rai. Currently, Metropolitan is developing a waste management system in the new model, using as anaerobic digestion method to help for disposal, which can generate electricity as a byproduct and this

construction is underway. The system is designed to support for Bio-waste disposal approximately 80 tons / day, divided into (1) use of machinery in separation of 40 tons / day and (2) separated at source 40 tons / day.

#### **4.1.1.2 Prototype community for study**

##### **(A) Criteria for selection**

According to profile of city, metropolitan has 58,810 households which scattered in 84 communities. This study will focus on the development of Bio-waste separation at source in 4 pilot communities. These are selected by high readiness and cooperate level which decided from another activity that ever been, recommended by municipality office. So, representative prototype community i.e. (1) Ban Rungruang-Bunruang, (2) Banpakthahan Nongbuarong, (3) 30 Kanya Pathana and (4) Korat Karuehat Thong, as a one community per zone of district elections.

##### **(B) Background**

The information of each community is used data from primary survey, observation with community board and leadership on May 2009, detail as following.

- Ban Rungruang-Bunruang. This community has 2,298 population or 778 households, registration with government. The responsible area is around 0.5 km<sup>2</sup>. Type of house is diversity such as; detached house, apartment or dormitory, trade building which approximately 50%, 30% and 20% in respectively. This is an open community which have a short cut road through out on 2 main streets and other community. This will be found of a business in community which has Bio-waste as a component, such as 13 of restaurants and 1 of fresh market.

- Banpakthahan Nongbuarong. This community has 1,783 population or 571 households, registration with government. The responsible area is around 0.1 km<sup>2</sup>. Type of house is only one style, small row block house as welfare of military. This is closed community which has no short cut road through out on main streets and other community. This will be found of a business in community which has Bio-waste as a component, such as 4 of restaurants and 1 of fresh market.

- 30 Kanya Pathana. This community has 1,872 population or 477 households, registration with government. The responsible area is around 0.3 km<sup>2</sup>, accounted for 4.96 % of metropolitan area. The types of house are diverse such as, detached house,



apartment or dormitory, trade building which approximately 20%, 30% and 50% in respectively. This is an open community which have a short cut road through out on 3 main streets and other community. This will be found of a business in community which has Bio-waste as a component, such as 38 of restaurants and 1 of fresh market.

- Korat Karuehat Thong. . This community is a little village which has 1,254 population or 346 households, registration with government. The responsible area is around 0.3 km<sup>2</sup>. Type of house is only one style, detached house. This is closed community which has no short cut road through out on main streets and other community. This will be found of a business in community which has Bio-waste as a component, such as 2 of restaurants and no fresh market.

#### **4.1.1.3 Classification of prototype community**

##### **(A) Criteria for classification**

According to background, these are summarized as criteria to classification type of community which classified by level of complexity which has 6 criteria, details as follows.

(1) Number of households: Number of households which more than or equal 500, is assigned to Complexity, if not as a non-complexity.

(2) Responsible areas: Responsible area which more than or equal 0.5 km<sup>2</sup>, is assigned to Complexity, if not as a non-complexity.

(3) Accommodation types: No dominant of accommodation type which more than 75%, is assigned to Complexity, if not as a non-complexity.

(4) Short cut roads: Short road which has through out on main streets and other community, is assigned to Complexity, if not as a non-complexity

(5) Number of restaurants: Number of restaurant which more than 10 places, is assigned to Complexity, if not as a non-complexity.

(6) Number of fresh markets: Number of fresh market which more than 1 place, is assigned to Complexity, if not as a non-complexity.

According to criteria, these classified types of community, level of complexity which has 4 types, detailed as follows.

(1) High Complexity Community or HCC, which has number of complexity level between 5-6 items of all criteria.



(2) Moderate Complexity Community or MCC, which has number of complexity level between 3-4 items of all criteria.

(3) Low Complexity Community or LCC, which has number of complexity level between 1-2 items of all criteria.

(4) Non Complexity Community or NCC, which has no complexity level of all criteria.

#### **B) Type of community**

The communities are divided into 4 types, classified by level of complexity (details in Table 4.1).

(1) Banrungruang-Bunruang as a representative of High Complexity Community (HCC) which has 6 items of all complexity criteria.

(2) Banpakthahan-Nongbuarong as a representative of Low Complexity Community (LCC) which has 2 items of all complexity criteria.

(3) 30- Kanya -Pathana as a representative of Moderate Complexity community (MCC) which has 4 items of all complexity criteria.

(4) Korat-Karuehat-Thong as a representative of Non-Complexity Community (NCC) which has 0 items of all complexity criteria.

**Table 4.1:** The classification of prototype communities by criteria of complexity level

Community	Criteria	Data	Complexity	
			Complex	Non-complex
<b>Ban rungruang- Bunruang</b> <i>(High Complexity Community)</i>	Number of household (household)	778	√	X
	Responsible area (km <sup>2</sup> )	0.5	√	X
	Dominant accommodation type < 75%	yes	√	X
	Short cut road through out main street	yes	√	X
	Number of restaurant (place)	13	√	X
	Number of fresh market (place)	1	√	X
	<i>Level of complexity</i>		<b>6</b>	
<b>Ban pakthahan - Nong buarong</b> <i>(Low Complexity Community)</i>	Number of household (household)	571	√	X
	Responsible area (km <sup>2</sup> )	0.1	X	√
	Dominant accommodation type < 75%	no	X	√
	Short cut road through out main street	no	X	√
	Number of restaurant (place)	4	X	√
	Number of fresh market (place)	1	√	X
	<i>Level of complexity</i>		<b>2</b>	
<b>30-Kanya- Pathana</b> <i>(Moderate Complexity Community)</i>	Number of household (household)	477	X	√
	Responsible area (km <sup>2</sup> )	0.3	X	√
	Dominant accommodation type < 75%	yes	√	X
	Short cut road through out main street	yes	√	X
	Number of restaurant (place)	38	√	X
	Number of fresh market (place)	1	√	X
	<i>Level of complexity</i>		<b>4</b>	
<b>Korat- Karuehat- Thong</b> <i>(Non- Complexity Community)</i>	Number of household (household)	346	X	√
	Responsible area (km <sup>2</sup> )	0.3	X	√
	Dominant accommodation type < 75%	no	X	√
	Short cut road through out main street	no	X	√
	Number of restaurant (place)	2	X	√
	Number of fresh market (place)	0	X	√
	<i>Level of complexity</i>		<b>0</b>	

#### **4.1.2 Mechanism for creating community network**

This step aims to study the process for establishing a network of Bio-waste separation at source, effective in supporting the electricity generation. The trial network will bring 2 main mechanisms to study and to compare the effectiveness of separation. The result will lead to set policy further. Details of each mechanism are as follows.

**4.1.2.1 Voluntary Mechanism (VM):** This mechanism is based on the principles of awareness creation and seeks cooperation in the separation of Bio-waste. The process of establishing has 3 steps as follows.

- **Establishment:** Establishment of facility for management (collection and transportation), staff, supporting unit, seminar coordination and information center. These are the cooperation between municipality and communities in early as a basic before next step.

- **Education:** Seminar and brainstorming with community to knowledge of waste management, particularly separation of Bio-waste, such as the benefits of separation, separation method and collected. Hearing problems and obstacles, including recommend from the community for highest effectiveness.

- **Encouragement:** Initiate, distributed bin for separation of bio-waste with the participants for attractive and convenient for activity. In assessment, distribution flag, admiration sign, to the household with good behavior as a reward.

**4.1.2.2 Incentive Mechanism (IM):** This mechanism is based on the principles of economic motivation for behavior change which is composed of Personal Business Mechanism (PM), Reward Mechanism (RM) and Community Business Mechanism (CBM). This study aims to comparison efficiency of bio-waste separation at source between types of Incentive Mechanism especially, Reward Mechanism (RM) and Community Business Mechanism (CBM). The Personal Business Mechanism (PM) is not concentrated in this study because that complexity for implementation. Therefore, the time and existing budget can not support this study. Details of each mechanism are as follows.

**(A) Reward Mechanism (RM):** This mechanism uses competition method with standard of pilot communities were made in the process of voluntary mechanism. Pilot communities that have efficiently pass criteria will be get prize money in each level. Revenue is accumulated in community fund and used for other activities, detail of reward and criteria is explained in Appendix C.





#### **4.1.4 Data collection and analysis**

The data is divided into 3 types such as (1) volume of Bio-waste in Bio-waste collector tank, (2) Proportion of waste components in Bio-waste collector tank and (3) % of Bio-waste in normal trash. Details are follows.

##### **4.1.4.1 Volume of Bio-waste in Bio-waste collector tank (VBs)**

To weigh volume of Bio-waste in Bio-waste collector tank every day at 18:00 and transfer to disposal site by small truck of the metropolitan transport. It will collect and weigh every tank and record a weight of each community per day (28 days for each mechanism).

##### **4.1.4.2 Proportion of components in Bio-waste collector tank (CBs)**

This data is indicated proportion of waste components in Bio-waste collector tank that villagers can be separated in each mechanism. These will collection data is 3 periods such as (1) voluntary mechanism, (2) reward mechanism and (3) community business mechanism. The data collection methods are as follows.

(1) To weigh volume of 5 Bio-waste collector tanks/ community/time by randomized and recorded by classified in two types, food waste and yard waste.

(2) Recorded data of each community within 9 days (6 working days and 3 weekend days) per month and collected for 1 month/mechanism. All of 9 days, random for collection data in 4 periods are 12.00, 13.30, 15.00 and 16.00 (same time and day with %BW collection)

(3) Calculated of each types as percentage, representative data of each mechanism.

##### **4.1.4.3 Percentage of Bio-waste in Public bin (BWb)**

This data indicates the changed of percentages of Bio-waste in the public bin in each community when the project in each mechanism was began.

A principle of this information is available for check consistent of VBs and BWb, observed behavior changed of community by mechanisms. Due to the reward and business mechanisms are added into the system. Therefore, efforts might have to add weight for the most to benefit. So, this is a metric that describes the changed behavior in each mechanism such as estimation of participant rate and sources of Bio-waste that added in separated tank.

These will collection data is 4 periods namely (1) before launch project, (2) voluntary mechanism, (3) reward mechanism and (4) community business mechanism. The data collection methods above are as follows.

(1) Collected sample waste from the public bin about 3 kg /trash and 25 trash /community, overall 75-80 kg./community/time. Then, 4 separated portion and take 2 portions to mixing, overall 30-40 kg. Then, 4 separated portion and take 2 portions, 15-20 kg to mixing and take to weigh in 3 types as (1) Bio-waste, (2) recyclable and (3) non- recyclable.

(2) Collected sample waste of each community within 9 times (6 working days and 3 weekend days) per month and collected for 1 month/mechanism. All of 9 days, random for collection data in 4 periods are 12.00, 13.30, 15.00 and 16.00 (same time and day with % CBW collection)

(3) Calculated proportion of each type as percentage and record as representative data of each mechanism.



4.2 Result

The results will be reported followed by data collection method and details of data in each method are reported in the Appendix C.

4.2.1 Volume of Bio-waste in Bio-waste collector tank (VBs)

This section will report weight of Bio-waste of each mechanism Details are as follows in Table 4.3 and shown comparison in Figure 4.1.

**Table 4.3:** The Volume of Bio-waste in Bio-waste collector tank (VBs) in each mechanism

Mechanisms	Details	Volume (Kg.) of each community				
		HCC	LCC	MCC	NCC	All area
Voluntary Mechanism (VM)	Week1	1,957	1,818	1,716	802	6,293
	Week2	1,809	2,328	2,568	906	7,611
	Week3	1,500	2,342	2,348	896	7,086
	Week4	2,135	3,575	3,071	865	9,646
	Amount	7,401	10,063	9,703	3,469	30,636
	kg/community/week	1,850.25	2,515.75	2,425.75	867.25	7,659.00
	kg/community/day	264.32	359.39	346.54	123.89	1,094.14
	kg/household/day	0.34	0.63	0.73	0.36	0.50
Reward Mechanism (RM)	Week1	2,120	3,383	3,057	945	9,505
	Week2	1,869	3,958	3,542	932	10,301
	Week3	2,315	4,767	4,861	1,154	13,097
	Week4	2,626	4,009	3,853	1,012	11,500
	Amount	8,930	16,117	15,313	4,043	44,403
	kg/community/week	2,232.50	4,029.25	3,828.25	1,010.75	11,100.75
	kg/community/day	318.93	575.61	546.89	144.39	1,585.82
	kg/household/day	0.41	1.01	1.15	0.42	0.73
Business Mechanism (CBM)	Week1	2,466	4,612	4,348	1,670	13,096
	Week2	2,601	4,359	3,997	1,515	12,472
	Week3	2,652	4,331	4,234	1,556	12,773
	Week4	1,703	4,360	4,374	1,580	12,017
	Amount	9,422	17,662	16,953	6,321	50,358
	kg/community/week	2,355.50	4,415.50	4,238.25	1,580.25	12,589.50
	kg/community/day	336.50	630.79	605.46	225.75	1,798.50
	kg/household/day	0.43	1.10	1.27	0.65	0.83

HCC is High Complexity Community which a represented by Banrungruang-Bunruang  
MCC is Moderate Complexity community which a represented by 30 Kanya Pathana  
LCC is Low Complexity Community which a represented by Banpakthahan Nongbuarong  
NCC is Non-Complexity Community which a represented by Korat Karuehat Thong

#### 4.2.2 Proportion of components in Bio-waste collector tank (CBs)

This section will report proportion of waste components in Bio-waste collector tank that villagers can be separated in each mechanism. Details are as follows in Table 4.4.

**Table 4.4:** The Percentage of components in Bio-waste collector tank in each mechanism

Community	Mechanisms					
	Voluntary		Reward		Community Business	
	% Food Waste	% Yard Waste	% Food Waste	% Yard Waste	% Food Waste	% Yard Waste
<b>High Complex</b>	91.06	8.94	88.89	11.11	88.75	11.25
<b>Low Complex</b>	94.68	5.32	92.56	7.44	92.13	7.87
<b>Moderate Complex</b>	94.28	5.72	92.23	7.77	91.84	8.16
<b>Non Complex</b>	95.48	4.52	92.62	7.38	91.89	8.11
<b>Average</b>	<b>93.87</b>	<b>6.13</b>	<b>91.57</b>	<b>8.43</b>	<b>91.15</b>	<b>8.85</b>

The proportion of components in Bio-waste collector tank is able to calculation volume of each composition in each motive mechanism from Equations 4.1 and 4.2 and result show in Table 4.5 as following;

##### - Food waste volume of each mechanism

$$FV = [(PF/100) * BV] \text{ ----- equation 4.1 where:}$$

FV = Food waste volume of each community (Kg/ household /day)

PF = Percentage of Food waste of each community

BV = Volume of Bio-waste separated of each community (Kg/ household /day)

##### - Yard waste volume each mechanism

$$YV = [(PY/100) * BV] \text{ ----- equation 4.2 where:}$$

YV = Yard waste volume of each community (Kg/ household /day)

PY = Percentage of Yard waste of each community

BV = Volume of Bio-waste separated of each community (Kg/ household /day)

**Table 4.5:** Volume of each component in Bio-waste collector tank

Community	Mechanisms								
	Voluntary			Reward			Community Business		
	BV	FV	YV	BV	FV	YV	BV	FV	YV
High Complex	0.34	0.31	0.03	0.41	0.36	0.05	0.43	0.38	0.05
Low Complex	0.63	0.60	0.03	1.01	0.93	0.08	1.10	1.01	0.09
Moderate Complex	0.73	0.69	0.04	1.15	1.06	0.09	1.27	1.17	0.10
Non Complex	0.36	0.34	0.02	0.42	0.39	0.03	0.65	0.60	0.05
Average	0.5	0.47	0.03	0.73	0.67	0.06	0.83	0.76	0.07

*BV = Volume of Bio-waste separated of each community (Kg/ household /day)*

*FV = Food waste volume of each community (Kg/ household /day)*

*YV = Yard waste volume of each community(Kg/ household /day)*

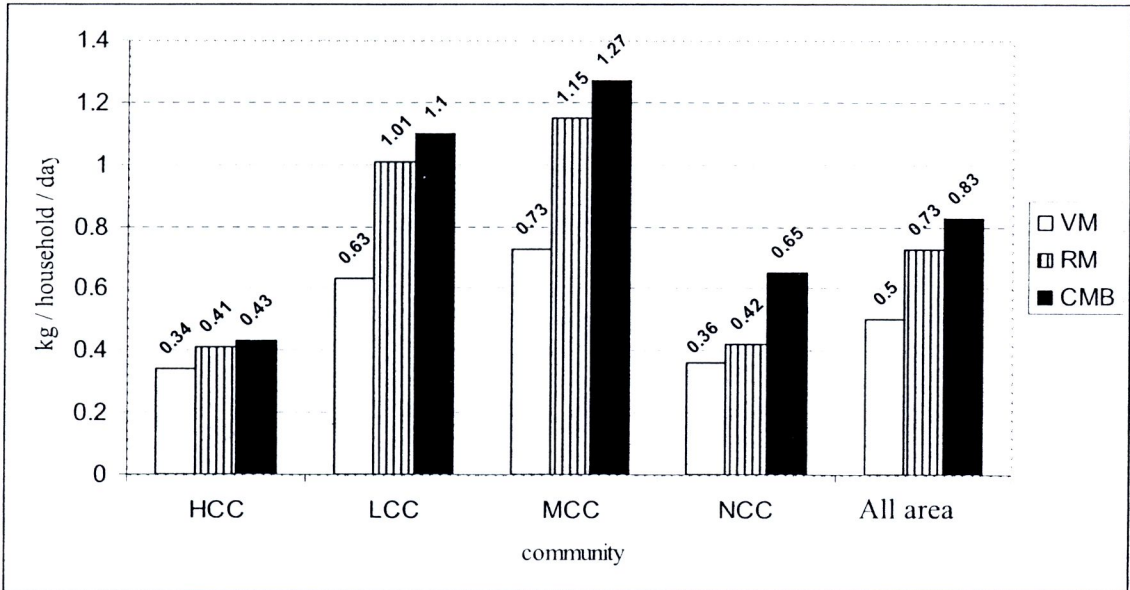
**4.2.3 Percentage of Bio-waste in public bin (BWs)**

This section reports the percentage of Bio-waste in the public bin in each community by 4 periods such as (1) Pre stage, (2) voluntary mechanism (VM), (3) reward mechanism (RM) and (4) community business mechanism (CBM). Details are as follows in Table 4.6 and shown comparison in Figure 4.2.

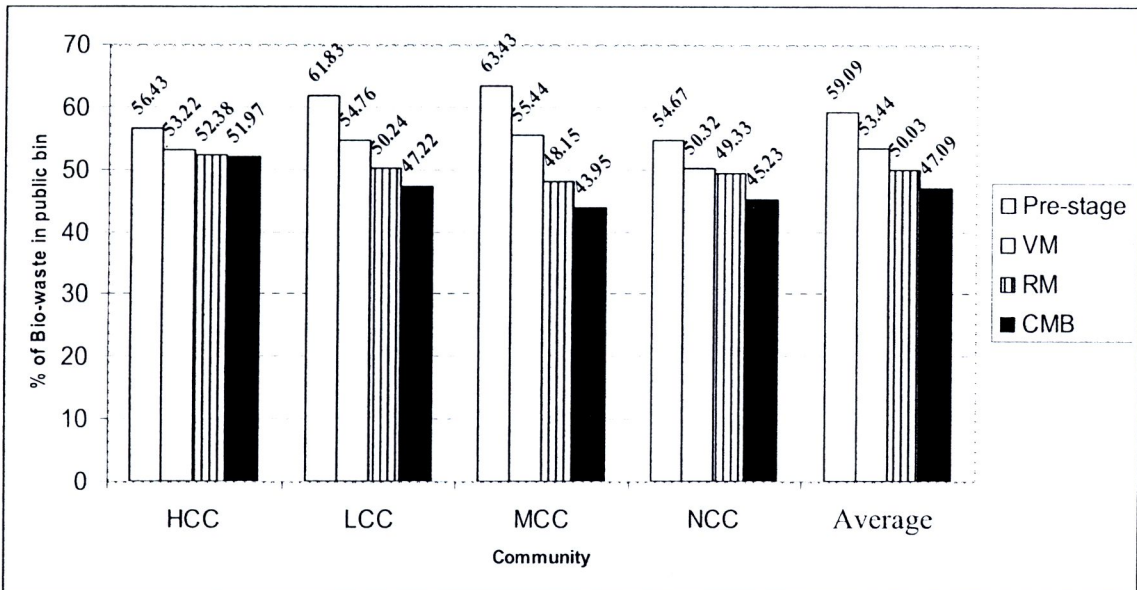
**Table 4.6:** The percentage of Bio-waste in public bin by surveyed (BWs)

Community	Percentage of Bio-waste in public bin(BWs)			
	Pre-stage	VM	RM	CBM
High Complex	56.43	53.22	52.38	51.97
Low Complex	61.83	54.76	50.24	47.22
Moderate Complex	63.43	55.44	48.15	43.95
Non Complex	54.67	50.32	49.33	45.23
Average	59.09	53.44	50.03	47.09





**Figure 4.1:** Comparison of Bio-waste in Bio-waste collector tank (VBs) in each mechanism



**Figure 4.2:** Comparison of % Bio-waste in public bin by surveyed (BW)



## 4.3 Discussion

### 4.3.1 Efficiency assessment

#### 4.3.1.1 Efficiency of mechanism for Bio-waste separated

The result found that incentive mechanism can be increasing the volume of Bio-waste every community significantly, to finding the efficiency of mechanism can calculation from Equations 4.3 and 4.4 as following;

##### (A) Equation of estimated

##### - Reward Mechanism efficiency

$$ERb = [(VRb - VVb)/VVb] * 100 \quad \text{----- equation 4.3 where:}$$

ERb = Efficiency of Reward Mechanism for Bio-waste separated

VRb = Volume of Bio-waste separated by Reward mechanism

VVb = Volume of Bio-waste separate by Voluntary Mechanism

##### - Community Business Mechanism efficiency

$$ECb = [(VCb - VVb)/VVb] * 100 \quad \text{----- equation 4.4 where:}$$

ECb = Efficiency of Community Business for Bio-waste separated

VCb = Volume of Bio-waste separated by Community Business Mechanism

VVb = Volume of Bio-waste separate by Voluntary Mechanism

##### (B) Summary of efficiency

- High Complexity Community (HCC): The efficiency of Reward mechanism is 20.59% and Community business mechanism is 26.74%.

- Low Complexity Community (LCC): The efficiency of Reward mechanism is 60.32% and Community business mechanism is 74.60%.

- Moderate Complexity Community (MCC): The efficiency of Reward mechanism is 57.53% and Community business mechanism is 73.97%.

- Non- Complexity Community (NCC): The efficiency of Reward mechanism is 16.67% and Community business mechanism is 80.56%.

Conclusion, Reward Mechanism is most effective with Low Complexity Community (LCC). Community business mechanism is most effective with Non-Complexity Community (NCC). In average, the efficiency of Reward mechanism is 46.00% and Community business mechanism is 66.0%. Details are as follows in table 4.7.

**Table 4.7:** The efficiency of incentive Mechanism for Bio-waste separation

Community	VVb	Reward Mechanism		Community business Mechanism	
		VRb	ERb	VCb	ECb
High Complex	0.34	0.41	20.59	0.43	26.47
Low Complex	0.63	1.01	60.32	1.10	74.60
Moderate Complex	0.73	1.15	57.53	1.27	73.97
Non Complex	0.36	0.42	16.67	0.65	80.56
Average	0.50	0.73	46.00	0.83	66.00

*VVb = Volume of Bio-waste separate by Voluntary Mechanism (kg/household/day)*

*VRb = Volume of Bio-waste separated by Reward mechanism (kg/household/day)*

*ERb = Efficiency of Reward Mechanism for Bio-waste separated (Percentage)*

*VCb = Volume of Bio-waste separated by Community Business Mechanism (kg/household/day)*

*ECb = Efficiency of Community Business for Bio-waste separated (Percentage)*

**(C) Estimation on Bio- waste separated of Metropolitan**

In whole picture, Nakornratcha Srima metropolitan has 58,810 households and Voluntary Mechanism can be separated Bio-waste at sources 0.5 Kg/household/day. So, that can be separation around 29 tons/day. Reward Mechanism has 46.0% of efficiency which can be separation around 43 tons/day. Community Business Mechanism has 66.0% of which can be separation around 49 tons/day.

**Table 4.8:** The estimated Volume of Bio-waste separated in metropolitan

Mechanism	Efficiency	Volume estimation (tons /day)
Voluntary Mechanism	-	29.41
Reward Mechanism	46.00%	42.94
Community Business Mechanism	66.00%	48.82



#### 4.3.1.2 Efficiency of mechanism for Food-waste separated

The result found that incentive mechanism can be decreasing the proportion of Food waste in every community , to finding the efficiency of mechanism can calculation from Equations 4.5 and 4.6 as follows;

##### (A) Equation of estimated efficiency

##### - Reward Mechanism efficiency

$$ERf = [(VRf - VVf)/VVf] * 100 \quad \text{----- equation 4.5 where:}$$

ERf = Efficiency of Reward Mechanism for Food-waste separated

VRf = Volume of Food-waste separated by Reward mechanism

VVf = Volume of Food-waste separate by Voluntary Mechanism

##### - Community Business Mechanism efficiency

$$ECf = [(VCf - VVf)/VVf] * 100 \quad \text{----- equation 4.6 where:}$$

ECf = Efficiency of Community Business for Food-waste separated

VCf = Volume of Food-waste separated by Community Business Mechanism

VVf = Volume of Food-waste separate by Voluntary Mechanism

##### (B) Summary of efficiency

- High Complexity Community (HCC): The efficiency of Reward mechanism is 16.13% and Community business mechanism is 22.58%.

- Low Complexity Community (LCC): The efficiency of Reward mechanism is 55.00% and Community business mechanism is 68.33%.

- Moderate Complexity Community (MCC): The efficiency of Reward mechanism is 53.62% and Community business mechanism is 69.57%.

- Non- Complexity Community (NCC): The efficiency of Reward mechanism is 14.71% and Community business mechanism is 76.47%.

Conclusion, Reward Mechanism is most effective with Low Complexity Community (LCC). Community business mechanism is most effective with Non-Complexity Community (NCC). In average, the efficiency of Reward mechanism is 42.55% and Community business mechanism is 61.70%. Details are as follows in table 4.9.

**Table 4.9:** The efficiency of incentive Mechanism for Food waste separation

Community	VVf	Reward Mechanism		Community business Mechanism	
		VRf	ERf	VCf	ECf
High Complex	0.31	0.36	16.13	0.38	22.58
Low Complex	0.60	0.93	55.00	1.01	68.33
Moderate Complex	0.69	1.06	53.62	1.17	69.57
Non Complex	0.34	0.39	14.71	0.60	76.47
Average	0.47	0.67	42.55	0.76	61.70

*VVf = Volume of Food waste separate by Voluntary Mechanism (kg/household/day)*

*VRf = Volume of Food waste separated by Reward mechanism (kg/household/day)*

*ERf = Efficiency of Reward Mechanism for Food waste separated (Percentage)*

*VCf = Volume of Food waste separated by Community Business Mechanism (kg/household/day)*

*ECf = Efficiency of Community Business for Food waste separated (Percentage)*

**(C) Estimation on Food waste separated of Metropolitan**

In whole picture, Nakornratcha Sriracha Metropolitan has 58,810 households and Voluntary Mechanism can be separated Food waste at sources 0.47 Kg/household/day. So, that can be separation around 28 tons/day. Reward Mechanism has 42.42% of efficiency which can be separation around 39 tons/day. Community Business Mechanism has 61.19% of which can be separation around 45 tons/day.

**Table 4.10:** The estimated Volume of Food waste separated in metropolitan

Mechanism	Efficiency	Volume estimation (tons /day)
Voluntary Mechanism	-	27.64
Reward Mechanism	42.55%	39.41
Community Business Mechanism	61.70%	44.69

### 4.3.2 Behavior assessment

The result show increasing of Bio-waste separated through reward and community business mechanism in significant. These impacted from behavior change of people, divided into two situations such as (1) increasing of new participant and (2) enhancing of separation practice. The decided of situation which dominant in each mechanism can observed by comparison of Volume of Bio-waste in Bio-waste collector tank (VBs) and Percentage of Bio-waste in public bin (BW<sub>s</sub>), then observation for situation and details as following;

#### 4.3.2.1 Methodology

The observation must be have new indicator to decision i.e. Percentage of estimated Bio-waste in public bin (BW<sub>adjust</sub>) compare with survey value, Percentage of Bio-waste in public bin (BW<sub>s</sub>). The calculation method as followed;

##### (A) Waste generation of each community (WG):

Nakornratcha Sriracha Metropolitan has 58,810 households, which generation waste around 220 tons/day. So, rate of waste generation per household is 3.74 Kg/household/day and waste generation of each community provided in Table 4.11

**Table 4.11:** Detail of Waste generation in each community by calculation

Community	Number of Household (household)	Generated (WG) (kg/community/day)
High Complex	778	2,909.72
Low Complex	571	2,135.54
Moderate Complex	477	1,783.98
Non Complex	346	1,294.04

##### (B) Volume of Bio-waste in public bin in Pre-Stage (VB<sub>adjust</sub>):

Volume of Bio-waste in public bin of each community is calculated by used Percentage of Bio-waste in public bin(BW<sub>s</sub>) in pre-stage and waste generation of each community, Calculation by below equation and result in table 4.12;

$$VB_{\text{adjust}} = WG * (BW_s (\text{pre-stage}) / 100) \text{ ----- equation 4.7}$$

VB<sub>adjust</sub> = Volume of Bio-waste in public bin in Pre-stage (kg/community/day)

WG = Waste generation of each community (kg/community/day)

BW<sub>s</sub> (pre-stage) = Percentage of Bio-waste in public bin on pre-stage (see on table 4.6)



Table 4.12: Bio-waste volume in each community by calculation

Community	Generated /community (WG) (kg/community/day)	BWs (pre-stage)	VB <sub>adjust</sub>
High Complex	2,909.72	56.43%	1,548.55
Low Complex	2,135.54	61.83%	1,169.42
Moderate Complex	1,783.98	63.43%	989.04
Non Complex	1,294.04	54.67%	651.16

(C) The estimated Bio-waste in public bin (BW<sub>adjust</sub>):

The estimated Bio-waste in public bin (BW<sub>adjust</sub>) is the Bio-waste in public bin that should be when calculation from Volume of Bio-waste in Bio-waste collector tank (VBs) of each mechanism (Table 4.4), equation for calculated as followed and result in Table 4.13.

$$BW_{adjust} = [(VB_{adjust} - VBs) / (WG - VBs) * 100]$$
 when; ---- equation 4.8

VB<sub>adjust</sub> = Volume of Bio-waste in public bin in Pre-stage (kg/community/day)

VBs = Volume of Bio-waste in Bio-waste collector tank (kg/community/day)

WG = Waste generation of each community (kg/community/day)

Table 4.13: The percentage of estimated value of in each mechanism (BW<sub>adjust</sub>)

Community	VM		RM		CBM	
	VBs	BW <sub>adjust</sub>	VBs	BW <sub>adjust</sub>	VBs	BW <sub>adjust</sub>
High Complex	264.32	52.08%	318.93	51.07%	336.50	50.73%
Low Complex	359.39	54.11%	575.61	47.75%	630.79	45.83%
Moderate Complex	346.54	54.63%	546.89	47.28%	605.46	44.66%
Non Complex	123.89	49.88%	144.39	48.99%	225.75	45.10%

(D) Situation of participated

The result of K-value is the difference percentage of Bio-waste in public bin from surveyed (BW<sub>s</sub>) and Bio-waste in public bin from estimation (BW<sub>adjust</sub>), by volume of Bio-waste in Bio-waste collector tank (VBs). Mean that, level of distribution of Bio-waste in public bin when motivated mechanism is implemented. K-value can be describe characterize of the community participation behavior into 2 situation as following, (K show in Table 4.14)

- **Situation 1, Positive K value (+K):** (1) K-value is positive value (+K) and closed zero that means Bio-waste separation practice into collector tanks is scattered throughout the community because percentage value of estimated and surveyed is closely. These possible to be, number of new participants increased when the motivate mechanism is implemented more than enhancement of separated practice.

(2) K-value is positive value (+K) and away from zero that means that means Bio-waste separation practice into collector tanks is not scattered throughout the community because percentage value of estimated and surveyed isn't closely.

These possible to be, participants enhance behavior of separation more than the increased the number of new participants when implementation of mechanism. Example of enhancement behavior, Bio-waste that ever outside public bin such as throw on street, feed animal and yard waste, these collected to Bio-waste collector tank for increase weight when incentive mechanism is added.

- **Situation 2, Minus K value (-K):** K-value is minus value (-K) these possible to be, (1) number of new participant increased more than +%DIF and (2) ability for separated of new participant is less than +%DIF.

**Table 4.14:** The difference value of BWs and BW<sub>adjust</sub> (K-value) in each mechanism

Community	VM			RM			CBM		
	BWs	BW <sub>adjust</sub>	K	BWs	BW <sub>adjust</sub>	K	BWs	BW <sub>adjust</sub>	K
High Complex	53.22	52.08	1.14	52.38	51.07	1.31	51.97	50.73	1.24
Low Complex	54.76	54.11	0.65	50.24	47.75	2.49	47.22	45.83	1.39
Moderate Complex	55.44	54.63	0.82	48.15	47.28	0.88	43.95	44.66	-0.7
Non Complex	50.32	49.88	0.45	49.33	48.99	0.35	45.23	45.1	0.14

*\*K-value is the difference value of BWs and BW<sub>adjust</sub> (BW<sub>s</sub> - BW<sub>adjust</sub>).*

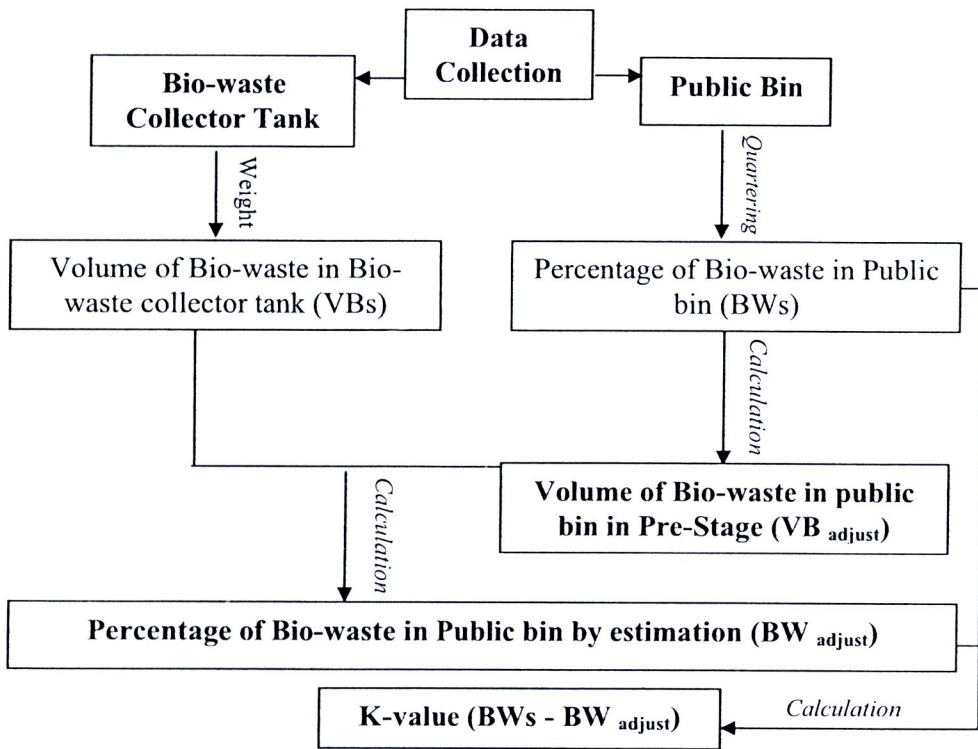


Figure 4.3: Diagram for estimation of K-values

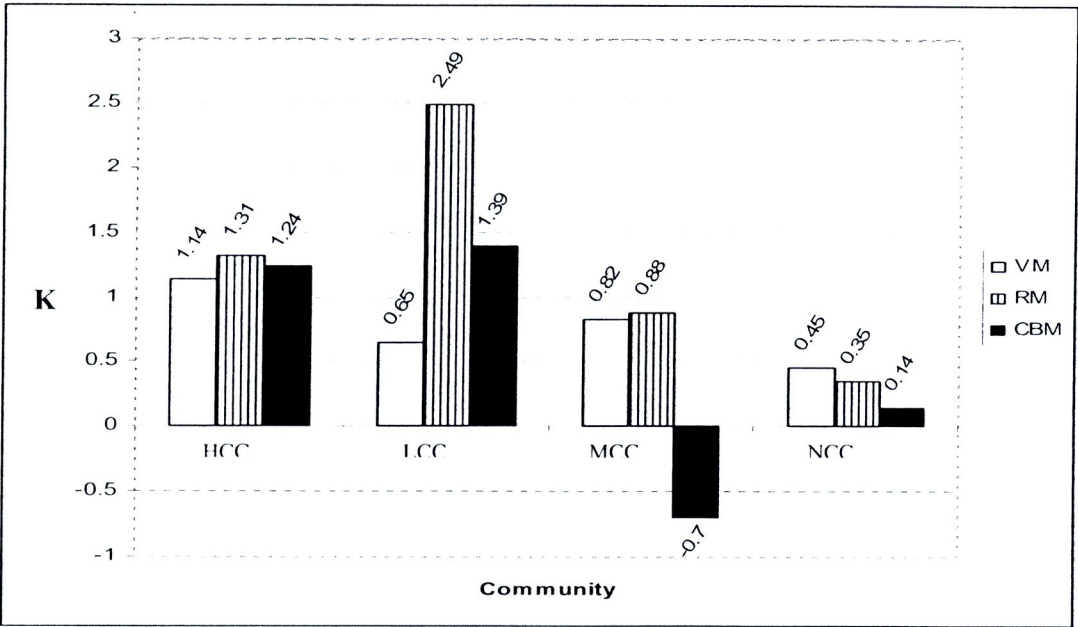


Figure 4.4: Comparison of K-value of each mechanism in pilot area



#### 4.3.3.2 Behavior of participation

From the result of K-value that can describe participation behavior of each mechanism, especially when Reward Mechanism and Community Mechanism are added in project as follows,

**(A) High Complexity Community (HCC):** This community has Bio-waste volume on pre-stage in the middle level (56.43%).

Voluntary Mechanism stage, the number of participant is not too much but highest ability of separated Bio-waste to collector tank when comparison with any community.

Reward Mechanism and Community Business Mechanism stage, the number of new participants increased no significantly but the old participants enhance separated behavior when comparison with any community.

**(B) Low Complexity Community (LCC):** This community has Bio-waste volume on pre-stage in relative high level (61.83%).

Voluntary Mechanism stage, the number of participant is relatively high vice from Non Complex Community.

Reward Mechanism stage, best of enhancing separated behavior when comparison with any community.

Community Business Mechanism stage, still best of enhancing separated behavior when comparison with any community and number of new participants increasing more than Reward stage.

**(C) Moderate complexity community (MCC):** This has Bio-waste volume on pre-stage in the highest level (63.44%).

Voluntary Mechanism stage, found that relatively high level of ability for separated Bio-waste to collector tank when comparison with any community (vice from HCC).

Reward Mechanism stage, the number of new participants relatively high increased when comparison with any community (vice from NCC).

Community Business Mechanism stage, highest increased of new participants when comparison with any community and number of new participants increasing more than Reward stage but low performance of separation Bio-waste.

**(D) Non-Complexity Community (NCC):** This community has Bio-waste volume on pre-stage in the lowest level (54.68%).

Voluntary Mechanism stage, the number of participant is in highest level when comparison with any community

Reward Mechanism stage, the number of new participants is highest increased when comparison with any community

Community Business Mechanism stage, the number of new participant is relatively high vice from Moderate Complex Community.

#### **4.4 Conclusions**

##### **4.4.1 Policy implications**

The study for establishment community network prototype to separate Bio-waste can be separated at source is in the most satisfactory level and that based on mechanisms in establishing i.e. Voluntary Mechanism, Reward Mechanism and Community Business Mechanism. These received the difference result in each mechanism significantly. According to result, community business mechanism has highest food waste separated, followed by reward mechanism and voluntary mechanism in respectively. So, the motivate mechanism which suitable to implementation on commercial city for received highest Food waste into project namely community business mechanism which could be prove result of survey research (Chapter 3), the economic incentive is influential for enhance Bio-waste separation practice. Details are summarized in Table 4.15.

Regarding on economic, the cost estimates of Bio-waste separation (at disposal site) for input to the disposal system approximately 450 baht / ton, including of labor and operation of machinery (Reference from expert). For this study, cost of incentive program is approximately 200 baht / ton for implementation. So, this has cost saving 250 baht / ton.

According to result, incentive mechanism able to increase efficiency on highest 17 tons / day, which helped to reduce overall system, costs about 4,250 baht / day or approximately 1,530,000 baht/year. The cost savings can be managed and planning for the incentive program to build the separation performance in the future. The advantage when implemented by incentive mechanism i.e. increasing opportunity to establishment Bio-waste to energy project

with small scale area , not need budget for created of separation mill which highly cost for set up. These able to esteem and distributed of Bio-waste to energy project around this country.

**Table 4.15:** Estimation of Food waste separated and economic advantage in prototype area

Estimation	Mechanism		
	Voluntary	Reward	Community business
<b>Scope of Household</b>			
Average volume of Food waste separated (kg/household/day)	0.47	0.67	0.76
Average costs saving from motivate mechanism (baht/household/day)	0.12	0.17	0.19
<b>Scope of Nakornratcha Sriracha Metropolitan</b>			
Average volume of Food waste separated (ton/metropolitan /day)	28	39	45
Average costs saving from motivate mechanism (baht/metropolitan /day)	7,000	9,750	11,250

#### 4.4.2 Management implications

Although, incentive mechanism is influential to enhance performance of Food waste separation from voluntary mechanism in all type of community, especially by community business mechanism (Table 4.9). In fact, incentive mechanism has many process and difficult to apply which from readiness of each municipality such as budget and staff. Thus, could not to conclusion on incentive mechanism is suitable for implemented with all of commercial city. Moreover, there has other motivated mechanism namely voluntary mechanism is able to replace of incentive mechanism with municipality that no ready to implemented by community business mechanism. So, this conclusion is show optional of management model which suitable to implementation when regarded by characteristic of commercial city, as a prototype for supported decision making to implement with other municipality in future.

According to result, the communities are divided in to 4 types, classified by level of complexity i.e. High Complexity Community (HCC), Moderate Complexity community (MCC), Low Complexity Community (LCC) and Non- Complexity Community (NCC). So, optional of management model are divided into 2 types i.e. (1) Implemented by suitable mechanism and (2) Implemented by integration mechanism which used the assessment of



ranking each motivate mechanism that impact with situation classified by type of community (Table 4.16). Details of model are as follows:

**Table 4.16:** The assessment of motivate mechanism in any situation by ranking

Factor	*Type of community/ **Rank			
	HCC	LCC	MCC	NCC
<b>1. Voluntary Mechanism</b>				
Volume of Food waste separated	4	2	<b>1</b>	3
Efficiency of Food waste separation	4	2	<b>1</b>	3
Increasing of new participant to project	4	2	3	<b>1</b>
<b>2. Reward Mechanism</b>				
Volume of Food waste separated	4	2	<b>1</b>	3
Efficiency of Food waste separation	3	<b>1</b>	2	4
Increasing of new participant to project	3	4	2	<b>1</b>
<b>3. Community business Mechanism</b>				
Volume of Food waste separated	4	2	<b>1</b>	3
Efficiency of Food waste separation	4	3	2	<b>1</b>
Increasing of new participant to project	3	4	<b>1</b>	2

\*Type of community, HCC is High Complexity Community. MCC is Moderate Complexity community, LCC is Low Complexity Community, NCC is Non- Complexity Community

\*\* Ranked, to ranking of result when compared by type of community. 1 =highest position (1<sup>st</sup>) 2= relatively high position (2<sup>nd</sup>) 3= relatively low position (3<sup>rd</sup>) 4= lowest position (4<sup>th</sup>)

#### 4.4.2.1 Implemented by suitable mechanism

This implementation is appropriate with small municipality or less number of community in area which no readiness for integration all of mechanism to implemented. Initially, the study characteristic of all community in area is necessary, to classified type of community. These used to decision suitable mechanism to implement. According to result, Community business mechanism is most suitable to implement with commercial city for receives highest performance of Bio-waste and Food waste separation, all type of community. In case of no ready for implemented by Community business mechanism, there have 2 optional for implemented by other mechanism under conditions which to supported decision making as following,

##### (A) Suitable city with Voluntary Mechanism

(1) According to Table 4.6, Moderate Complexity Community has highest volume and efficiency of Food waste separation (1<sup>st</sup> ranked) in process of voluntary mechanism. Meaning that, voluntary mechanism is most suitable to implementation with

commercial city which has Moderate Complexity Community as a majority in area. This able to received maximum efficiency of Food waste separation. Although, incentive mechanism is able to increasing of efficiency but that has highest on another type of community.

(2) According to Table 4.6, Non Complexity Community has highest increase number of new participant to project (1<sup>st</sup> ranked) in process of voluntary mechanism. Meaning that, voluntary mechanism is suitable to implementation with commercial city this has Non Complexity Community as a majority in area. This able to received maximum number of new participant to project which advantage in future.

So, commercial city which has Moderate Complexity Community and Non Complexity Community as a majority proportion in area is most suitable to apply voluntary Mechanism, as an alternative to implementation other than community business mechanism.

#### **(B) Suitable city with Reward Mechanism**

(1) According to Table 4.6, Low Complexity Community has highest efficiency of Food waste separation (1<sup>st</sup> rank) in process of reward mechanism. Meaning that, Reward mechanism is suitable to implementation with commercial city which has Low Complexity Community as a majority in area. This able to received maximum efficiency of Bio-waste and Food waste separation. Although, Moderate Complexity Community has highest volume of Food waste separated but vice from Low Complexity Community in terms of efficiency which not be worth for implement.

(2) According to Table 4.6, Non Complexity Community has highest increase number of new participant to project (1<sup>st</sup> rank) in process of reward mechanism. Meaning that, reward mechanism is suitable to implementation with Commercial city which has Non Complexity Community as a majority in area. This is able to receive maximum number of new participant to project which advantage in future

So, commercial city which has Low Complexity Community and Non Complexity Community as a majority proportion in area is most suitable to apply reward mechanism, as an alternative to implementation other than community business mechanism.



#### **4.4.2.2 Implemented by integration mechanism**

This implementation is appropriate with large municipality or high number of community in area which readiness for integration all of mechanism to implemented. Initially, the study characteristic of all community in area is unnecessary which able to study along with implementation. Although, community business mechanism is most suitable to implement with commercial city for receives highest performance of Bio-waste and Food waste separation, all type of community, but this is unsuitable with all type of community. For example, some community has quite low increasing of efficiency such as High Complexity Community has efficiency in process of community business which increased from voluntary mechanism accounted for 22.58%, whereas Non Complexity Community is 76.47% (Table 4.9). Then, High Complexity Community is unsuitable for implemented by community business mechanism which not be worth for implement when comparison with Non Complexity Community. So, this model is used highest ranked in any situation (Table 4.16) to assign suitable mechanism with each type of community for implementation i.e.

##### **(A) Suitable mechanism with Low Complexity Community**

According to Table 4.6, Low Complexity Community has highest efficiency of Food waste separation (1<sup>st</sup> rank) when comparison with other community in process of reward mechanism. Meaning that, voluntary mechanism is most suitable to implementation with Low Complexity Community. This able to received maximum efficiency of Food waste separation.

According to Table 4.6, voluntary mechanism has influential for increase number of new participant to project with Low Complexity Community in highest position (2<sup>nd</sup> rank) when comparison with other mechanism. Meaning that, voluntary mechanism is suitable to implementation with Low Complexity Community. This able to received maximum number of new participant to project which advantage in future

So, Low Complexity Community is suitable to implement voluntary mechanism in the early of project which for attractive new participant, then followed by reward mechanism to enhance performance of separation. This is a suitable model for implement with Low Complexity Community



### **(B) Suitable mechanism with Moderate Complexity Community**

According to Table 4.6, Moderate Complexity Community has highest efficiency of Food waste separation (1<sup>st</sup> rank) when comparison with other community in process of voluntary mechanism. Meaning that, voluntary mechanism is most suitable to implementation with Moderate Complexity Community. This able to received maximum efficiency of Food waste separation.

According to Table 4.6, community business mechanism is influential for increasing the number of new participant to project with Moderate Complexity Community in highest position (1<sup>st</sup> rank) when comparison with other mechanism. Meaning that, community business mechanism is suitable to implementation with Moderate Complexity Community. This able to received maximum number of new participant to project which advantage in future

So, Moderate Complexity Community is suitable to implement voluntary mechanism in the early of project which for highest performance of separation. Then, followed by community business mechanism to increasing number of new participant to project which enhances efficiency of practice in future, if needed. This is a suitable model for implement with Moderate Complexity Community

### **(C) Suitable mechanism with Non Complexity Community**

According to Table 4.6, Non Complexity Community has highest efficiency of Food waste separation (1<sup>st</sup> rank) when comparison with other community in process of community business mechanism. Meaning that, community business mechanism is most suitable to implementation with Non Complexity Community. This able to received maximum efficiency of Food waste separation.

According to Table 4.6, voluntary mechanism has influential for increase number of new participant to project with Non Complexity Community in highest position (2<sup>nd</sup> rank) when comparison with other mechanism. Meaning that, voluntary mechanism is suitable to implementation with Non Complexity Community. This able to received maximum number of new participant to project which advantage in future

So, Non Complexity Community is suitable to implement voluntary mechanism in the early of project which for attractive new participant, then followed by community business mechanism to enhance performance of separation. This is a suitable model for implement with Low Complexity Community

**(D) Suitable mechanism with High Complexity Community**

According to Table 4.6, High Complexity Community has no dominant situation in all factors including, efficiency of Food waste separation and increasing of new participant to project. Regarding of result, this has quite low increasing on efficiency of Food waste separation by incentive mechanism (Table 4.9).

So, High Complexity Community is suitable to implement voluntary mechanism in all period of project and unnecessary to be implemented by incentive mechanism. This is a suitable model for implementing with High Complexity Community